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A Crown Cover Chart For Oak Savannas

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Although oak savannas have been defined in many ways, they are characterized by scattered trees, largely comprised of oaks, and a sparse ground layer rich in grasses and forbs (Haney and Apfelbaum 1990). Nuzzo (1986, p. 11) more specifically defined oak savannas as plant communities "...dominated by oaks having between 10 and 80 percent canopy, with or without a shrub layer, and herbaceous cover, predominately a grassy layer, composed of both prairie and forest communities..." From these definitions, it is apparent that a certain range in crown coverage of trees is a characteristic of oak savannas central to their definition and thus their preservation, restoration, and management. This paper presents a crown cover chart for estimating the crown coverage of open-grown oaks and hickories in oak savannas and similar plant communities.

Application

The crown cover chart (fig. 1) can be used to estimate the crown cover of trees as a percent of total area. Potential applications of the chart include monitoring changes in savanna crown cover, determining needed reductions in crown cover, and defining the savanna "state." In restoring savannas that have grown into closed canopy stands, you can use the chart to estimate initial crown cover before restoration work is begun and again after crown cover has been reduced.

To use the chart, you need to estimate two stand parameters from sample plots within a savanna: (1) basal area in square feet per acre, and (2) number of trees per acre. Variation in tree size and spatial distribution determines how many sample points you must have to attain a given degree of accuracy in estimation. In most applications, at least 10 well-distributed sample points will be required to obtain acceptable estimates.

To determine the average basal area in square feet per acre, use the point sampling method and an angle gauge or prism (Hays *et al.* 1981, Husch *et al.* 1982). This variable-radius plot sampling method can be used to estimate average basal area per acre of trees above some minimum threshold diameter (e.g., 4 inches d.b.h.). In the Eastern United States, the 10-factor (English unit) prism has been widely used. If that prism or angle gauge is used, each tree counted at a sample point represents 10 square feet of basal area per acre.

In addition to obtaining a tree count at each point-sample plot with a prism or angle gauge, you'll also need to obtain tree counts on fixed-radius plots. To do this, use 1/20-acre plots (26.4 feet in radius) centered on each point-sample plot. These tree counts then are used to estimate number of trees per acre.

See table 1 for an example of how the chart can be applied. In this example, the number of trees sampled on 10 basal area factor-10 plots total 38 (24 post oaks, 4 white oaks, 4 black oaks, 4 hickories, and 2 other species[1]). Because each tree represents 10

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[1] *Because "other" species were a minor component of this savanna, they were included in crown cover estimates even though the crown cover chart may not accurately estimate their crown areas.*

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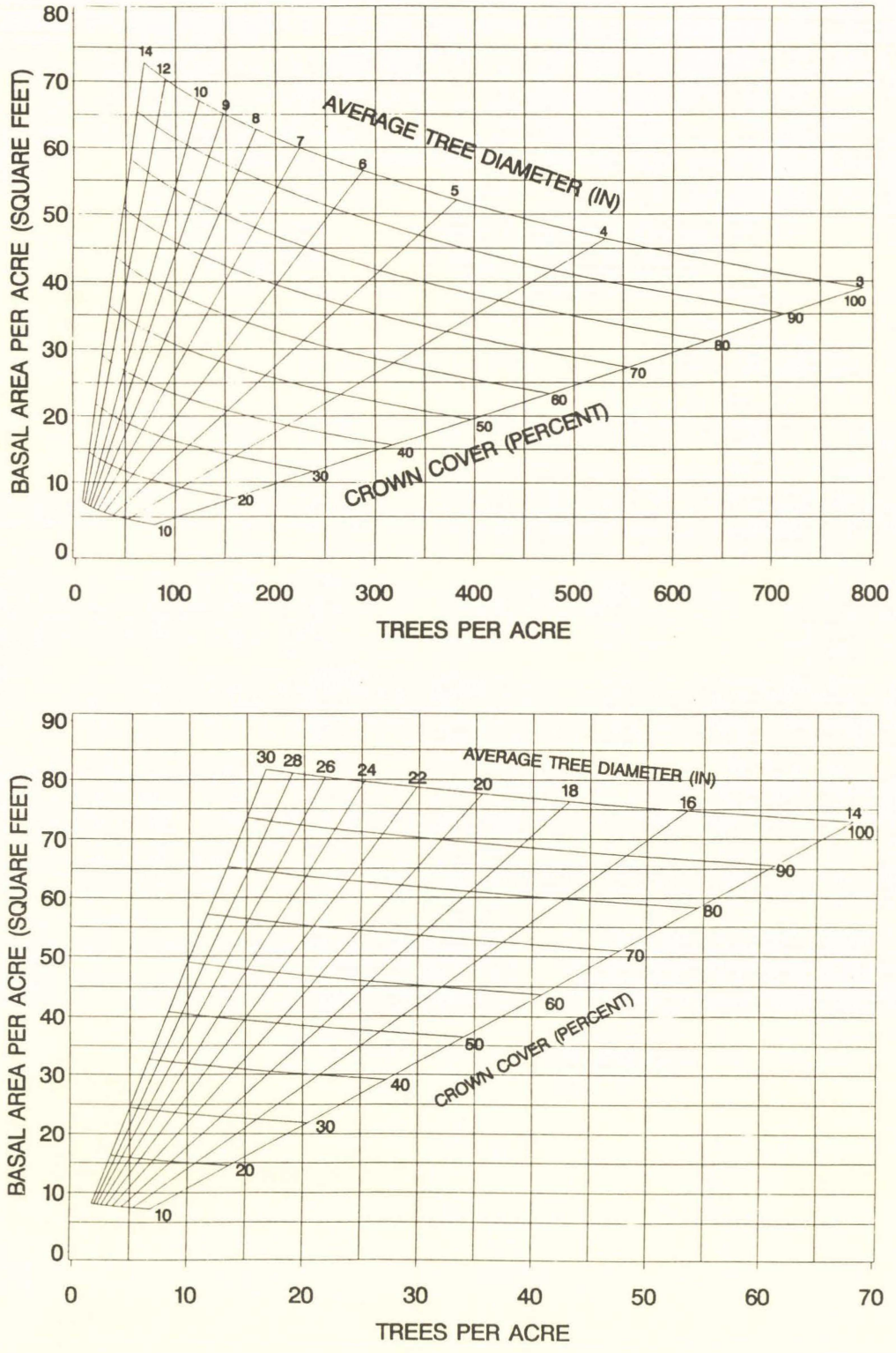

Figure 1.—*Relation between tree crown cover and tree basal area, numbers, and average diameter in open-grown oak-hickory stands for stands ranging in mean diameter from 3 to 14 inches (upper chart) and stands ranging from 14 to 30 inches (lower chart). (The relation assumes that trees are oaks or hickories at maximum crown expansion for a given diameter. Stands at or above 100 percent crown cover represent closed-canopy forests. Percent crown cover is based on the maximum crown area equation of Krajicek* et al. *(1961). Average tree diameter is the diameter of the tree of average basal area.)*

Table 1.—*Inventory of trees on 10 point-sample plots and 10 fixed-radius plots in a post oak (*Quercus stellata *Wangenh.) savanna restoration project, Mark Twain National Forest, Missouri*

Point-sample tree count by species (10-factor prism)						
Post oak	White oak	Black oak	Hickory	Other	Total	1/20-acre tree count
24	4	4	4	2	38	24

square feet of basal area and there are 10 sample points, the estimated basal area is 38 x 10/10 or 38 square feet per acre. The total tree count on the ten 1/20-acre fixed-radius plots (1/2-acre) is 24. Thus, the estimated number of trees per acre is 24/0.5 or 48.

With this information, you can estimate the average crown cover for the savanna from the crown cover chart (fig. 1). First, locate 48 trees per acre on the horizontal axis of the upper chart, which pertains to stands with trees that average 3 to 14 inches in diameter measured 4.5 feet above ground (d.b.h.). Then locate the corresponding basal area value by moving vertically along the basal area scale until a value of 38 is reached. Note that this intersection of basal area and trees per acre occurs between the 50- and 60-percent crown cover curves, which are shown as diagonal lines. By interpolation, crown cover in this case is thus approximately 55 percent.

In stands where crown cover initially exceeds 100 percent, individual tree crowns are likely to be smaller for a given d.b.h. than that represented by their potential crown areas. Consequently, when stand density is reduced by burning or other means, actual crown area may be temporarily smaller than that shown by the crown cover chart. Theoretically, the crowns of residual overstories should expand over time to the potential areas assumed by the chart. However, the crowns of some trees may die back from sudden exposure. Dieback is most likely to occur in trees of suppressed and intermediate crown classes, especially in stands drastically reduced in density in one cultural operation. On the other hand, there is evidence that crown areas of dominant oaks in closed stands do not differ from those in open-grown stands (McGill *et al.*, in press). Therefore, the crown areas of large relic trees persisting from an earlier savanna may be accurately represented by the crown cover chart even when canopies are closed.

The crown cover chart provides a potentially useful tool for describing, restoring, and managing oak savannas because it: (1) establishes a standard for describing crown cover, (2) establishes a standard for defining the range in crown cover that characterizes the savanna state, (3) provides reproducible and objective estimates of crown cover, and (4) requires estimates of only two easily determined stand parameters: basal area per acre and number of trees per acre. The chart will be less useful in savannas with considerable overlap in tree crowns and where oaks and hickories do not predominate.

How the Chart was Developed

The crown cover chart is based on the maximum crown diameter a tree of a given d.b.h. can attain. In turn, that crown diameter is estimated from the "maximum crown area" equation, which was derived from measurements of crown and d.b.h. of 148 open-grown trees including white oak (*Quercus alba* L.), black oak (*Q. velutina* Lam.), northern red (*Q. rubra* L.), and shagbark hickory (*Carya ovata* (Mill.) K. Koch) (Krajicek *et al.* 1961). Because differences among species in crown diameter/d.b.h. relations were small, species were combined to produce a single maximum crown area (MCA) equation. The equation accounts for 97 percent of the variation in observed relative crown area and is given by:

$$MCA = 0.0175 + 0.0205D + 0.0060D^2 \qquad (1)$$

where, MCA is percent of an acre and D is d.b.h. in inches (Krajicek *et al.* 1961).

Equation 1 can thus be used to estimate the relative area of tree crowns (percent crown cover) in open-grown stands by summing the MCA's of all trees on an acre. Because of the high correlation between crown area and stem area at d.b.h., the resulting sums produce accurate estimates of relative crown cover when there is no overlap between crowns. Accordingly, the equation should be used only to estimate crown cover in stands where the sum of MCA's for all trees on an acre is 100 percent or less and trees are well dispersed. The equation is thus potentially applicable to estimating tree crown cover in oak savannas. In that context, crown cover is defined as

the proportion of an acre (or other unit area) covered by the vertical projection of tree crowns onto an acre. The equation assumes that tree crowns are circular.

We used the stocking chart format developed by Gingrich (1967) to graphically express crown cover in relation to other stand parameters. The method assumes that a given measure of relative stand density (or, in our case, relative crown cover) can be graphically expressed as a function of mean stand diameter, basal area per acre, and number of trees per acre. Expressing those relations in a chart requires that equation 1 be extended to the stand (population) level by the following relation:

$$SCC = 0.0175N + 0.0205\sum D + 0.0060\sum D^2 \quad (2)$$

where SCC is stand crown cover as a *percent of an acre*, N is the number of trees per acre above a given minimum threshold diameter, $\sum D$ is the sum of tree diameters at d.b.h., and $\sum D^2$ is the sum of the squared diameters. Solving equation 2 for N = 1 thus yields crown cover estimates identical to equation 1.

The chart (fig. 1) and equation 2 produce comparable estimates of crown cover. Equation 2 produces more accurate estimates of crown cover because a given variance in tree diameters must be assumed to construct the chart; but in equation 2, this variance is inherent in the relation between $\sum D$ and $\sum D^2$ for a given sample of diameters (Gingrich 1967). However, comparisons of estimates across the range of diameter distributions likely to occur in oak savannas revealed that the two methods of estimation will be within ±5 percent more than 95 percent of the time.

Literature Cited

Gingrich, Samuel F. 1967. **Measuring and evaluating stocking and stand density in upland hardwood forests in the Central States.** Forest Science. 13(1): 38-30.

Haney, Alan; Apfelbaum, Steven I. 1990. **Structure and dynamics of midwest oak savannas.** In: Sweeney, James S., ed. Management of dynamic ecosystems, proceedings of the symposium; 1989 December 5; Springfield, IL. West Lafayette, IN: North Central Section, The Wildlife Society: 19-30.

Hays, Robert L.; Summers, Cliff; Seitz, William. 1981. **Estimating wildlife habitat variables.** Publ. FWS/OBS-81/47. Washington, DC: U.S. Department of the Interior, Fish and Wildlife Service. 111 p.

Husch, Bertram; Miller, Charles I.; Beers, Thomas W. 1982. **Forest mensuration.** New York, NY: Wiley and Sons. 402 p.

Krajicek, John E.; Brinkman, Kenneth A.; Gingrich, Samuel F. 1961. **Crown competition—a measure of density.** Forest Science. 7(1): 35-42.

McGill, D.W.; Rogers, R.; Martin, A.J.; Johnson, P.S. 1994. **Measuring stocking in northern red oak stands in Wisconsin.** Northern Journal of Applied Forestry. [In press].

Nuzzo, Victoria A. 1986. **Extent and status of midwest oak savanna: presettlement and 1985.** Natural Areas Journal. 6(2): 6-36.

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